

Available online at www.sciencedirect.com

Energy Procedia 5 (2011) 343–347

Energy
Procedia

IACEED2010

A Neural Network Forecasting Model of Beijing Environment Quality Based on Set Pare Analysis

Zhang Dingtian^a, Zhang Xiaoxi^{b*}^aDepartment of Computer Science and Technology, Tsinghua University, Beijing, 100084, P.R. China^bNormal College of Beijing Union University, Beijing, 100011, P.R. China

Abstract

By using neural networks, Beijing environment quality is forecasted, and connection number and total partial connection number of the set pair analysis (SPA) are obtained. Principal factors and development trend are sequenced based on absolute relative error between sample value x_i and predominant value y_i so as to set up a mathematics model of forecasting Beijing environment quality. The instance analysis shows that it's a scientific and practicable method of system analysis with a higher forecasting accuracy.

© 2011 Published by Elsevier Ltd. Open access under [CC BY-NC-ND license](http://creativecommons.org/licenses/by-nc-nd/3.0/).

Selection and peer-review under responsibility of RIUDS

Keywords: Environment quality; SPA; Neural network; Forecasting model

1. Introduction

We know that the environment quality is of great importance to the peoples' livelihood. SPA is a new system analysis theory put forward by Zhao Keqin, which is based on the analysis of fixed quantity to system on identical discrepancy contrary [1-3]. Artificial neural networks can process the trading data more easily, since there is no need to set up a mathematical model of high accuracy. This paper aims at seeking the relation between Beijing environment quality and the forecasting factors, and forecasting Beijing environment quality as a complex system. In this paper, we apply neural networks to forecasting Beijing environment quality, sequence the principal factors and analyze the development trend using connection number and total partial connection number of the set pair analysis (SPA) [4-6]. The feasibility

* Corresponding author. Tel.: +86-13693211057; +86-13693258970.

E-mail address: sftxiaoxi@buu.edu.cn; zuoxun4444@yahoo.cn.

of model is verified by instance, and it provides scientific basis for the decision of government departments.

2. Building of Neural Network Model Based on SPA

The basic concept of SPA is to consider the problem as both certain and uncertain system, and a formula of related degree: $\mu = a + bi + cj$ is used to describe all kinds of uncertainties, in which a stands for identity degree, b is deviation degree and c is complementary degree. a , b and c satisfy the reduction to unity $a + b + c = 1$, where the total partial contact number is

$$\partial_{-}^{+}\mu = a/(a+b) + [b/(b+c) + b/(a+b)]i + c/(b+c)j \quad (1)$$

The calculating results can be observed when $j = -1, i \in [-1, 1]$, and the developing trend of the environment quality can be analyzed so as to determine the weight w_i ($i = 1, 2, 3, 4$), which influences its primary factors. The artificial neural networks is an artificial intelligent system imitating the biological networks [7-10], which inputs the primary factors data into BP network as shown in figure 1, and achieves the internal expression of automatic learning by anti-propagation algorithm. The whole processes includes that firstly the weighted input data are passed to the hidden nodal points and calculated by action function

$$f(x) = \frac{1}{1 + e^x} \quad \text{to output nodal points, then, the output data between the networks and expectation are}$$

compared. If the error is less than the prescribed value, the learning will be over. But if not, the error will be propagated backwards and the weights and threshold data are adjusted progressively. In this way, the circulation continues till the error meets the demands.

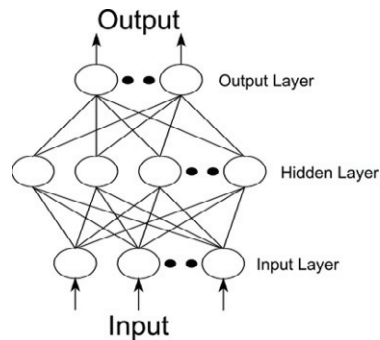


Fig. 1. BP neural network structure

Beijing environment quality (y) involves following primary factors: rate of harmless disposal of the domestic garbage (X_1), rate of waste water disposed (X_2), coverage of city green areas (X_3), and the percentage of days with air quality at or better than grade II (X_4), in which $y = \frac{1}{4} \sum_{i=1}^4 X_i$. Thinking of the maximum coverage of city green areas is about 50%, in order to make standardize X_3 of measures with

others, so treat with double X_3 . Defining evaluation index of environment quality: in 0-0.40 is considered bad, in 0.40-0.60 is considered general, in 0.60-0.80 is considered good, in 0.80-1.0 is considered better.

The absolute relative error between sample value x_i and predominant value y_i is defined [11]:

$$\delta_i = \left| \frac{x_i - y_i}{y_i} \times 100\% \right| \quad (2)$$

When $\delta_i \leq 0.10$ marked with “identical”; $0.10 < \delta_i \leq 0.15$: “discrepancy”; $\delta_i > 0.15$:

“contrary”. SPA model $\mu(X_k, y) = a_k + b_k i + c_k j$ is established: $a_k = \frac{\text{cardinal "i"}}{n}$,

$b_k = \frac{\text{cardinal "d"}}{n}$, $c_k = \frac{\text{cardinal "c"}}{n}$. $\partial^+ \mu(X_k, y)$ is got by formula(1), and determined the weight

$w_i (i = 1, 2, 3, 4)$ and forecasting Beijing environment quality by neural networks.

3. The Instance

Now we begin to forecast Beijing environment quality. Table 1 shows the statistical data from 2000 to 2009. The $\delta_i (i = 1, 2, 3, 4)$ are got by formula (2), as shown in table 1. For example, between $X_1(2000-2009)$ and y : $\delta_1 \leq 0.10$ is recorded on 3, $0.10 < \delta_1 \leq 0.15$ is recorded on 6, $\delta_1 > 0.15$ is recorded on 1.

Table 1. Evaluation Index of Beijing Environment Quality and Primary Factors Indicators, 2000-2009

Year	Domestic garbage disposed (%)	Waste water disposed (%)	City green areas (% × 2)	Days ≥ grade II (%)	Evaluation index
	$X_1 (\delta_1)$	$X_2 (\delta_2)$	$X_3 (\delta_3)$	$X_4 (\delta_4)$	y
2000	50.1 (0.049)	39.4 (0.252)	73.0 (0.385)	48.4 (0.082)	0.53
2001	53.6 (0.043)	42.0 (0.250)	77.6 (0.386)	50.7 (0.095)	0.56
2002	58.6 (0.025)	45.0 (0.251)	81.2 (0.351)	55.6 (0.075)	0.60
2003	63.4 (0.012)	50.1 (0.220)	81.8 (0.274)	61.4 (0.044)	0.64
2004	79.3 (0.134)	53.9 (0.256)	83.8 (0.199)	62.6 (0.104)	0.70
2005	83.4 (0.135)	62.4 (0.151)	84.0 (0.143)	64.1 (0.127)	0.74
2006	89.5 (0.139)	73.8 (0.061)	85.0 (0.081)	66.0 (0.160)	0.79
2007	92.9 (0.153)	76.2 (0.055)	86.0 (0.067)	67.4 (0.163)	0.81
2008	95.4 (0.134)	78.9 (0.062)	87.0 (0.034)	74.9 (0.105)	0.84
2009	95.8 (0.118)	80.0 (0.067)	88.8 (0.036)	78.1 (0.089)	0.86

Therefore we get $\mu(X_1, y) = \frac{3}{10} + \frac{6}{10}i + \frac{1}{10}j$. In like manner, we acquire

$$\mu(X_2, y) = \frac{4}{10} + \frac{0}{10}i + \frac{6}{10}j, \quad \mu(X_3, y) = \frac{4}{10} + \frac{1}{10}i + \frac{5}{10}j, \quad \mu(X_3, y) = \frac{5}{10} + \frac{3}{10}i + \frac{2}{10}j.$$

According to formula (1) the total partial contact number is

$$\partial_-^+ \mu(X_1, y) = 0.33 + 1.52i + 0.14j, \quad \partial_-^+ \mu(X_2, y) = 1.0 + 0i + 1.0j,$$

$$\partial_-^+ \mu(X_3, y) = 0.80 + 0.37i + 0.83j, \quad \partial_-^+ \mu(X_3, y) = 0.63 + 0.98i + 0.40j.$$

Let $i = 0.5, j = -1$, and we get

$$\partial_-^+ \mu(X_1, y) = 0.95, \quad \partial_-^+ \mu(X_2, y) = 0, \quad \partial_-^+ \mu(X_3, y) = 0.16, \quad \partial_-^+ \mu(X_3, y) = 0.72.$$

Thus it can be seen that the development trend is $X_1 > X_4 > X_3 > X_2$.

The BP network forecasting model has 4 input nodes, 6 hidden nodes, and 1 output node. We send 9 groups of statistical data which are typical learning samples into the BP networks. The data are strained about 15000 times and we get the BP 8 model. Then we take all the 10 groups in the model to test. The quasi-degree is satisfying. The 2 non-learning sample groups can satisfy the error requirements of model. The model is also of wide application. The comparison between model output and actual data are shown in Figure 2.

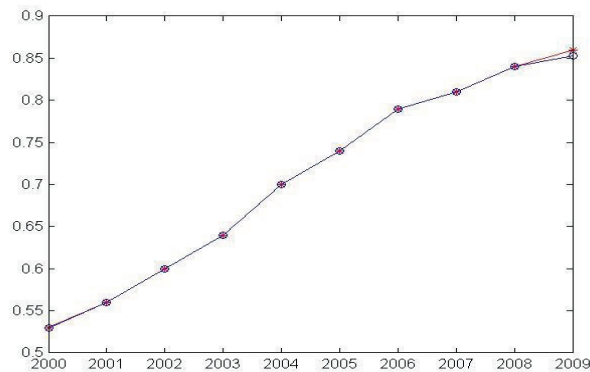


Fig. 2. Output data compared with sample

4. Conclusion

The neural networks which have nonlinearity mapping ability are applied to learning and forecasting of Beijing environment quality, and it provides scientific basis for the environment quality improvement. Its forecasting validity in the complex and random system is reliable and satisfying. The principal factors and the development trend are sequenced by partial connection number, and it offers a new thinking and approach to the factors analysis of Beijing environment quality. This model stresses on the relativity and fuzziness of information processing. This approach is simple and convenient, and the forecasting result is

more intuitive, accurate and reliable. It also embodies and analyzes the dynamic feature of environment quality of Beijing scientifically.

References

- [1] Beijing Bureau of Statistics. Beijing Statistics Almanac. Beijing: Statistics Press of China, 2000–2009.
- [2] Wen Jiabao. Report on the work of the government. *Journal of Beijing Review* 2010, 53(12):p1–8
- [3] Zhao Keqin. *Set Pair Analysis and Its Elementary Application*. Science and Tech. Hangzhou: Press of Zhejiang; 2000: 15–67 (in Chinese)
- [4] Zhang Xiaoxi. *Control Theory of Mathematics and Application*. Chifeng: Science and Tech. Press of Inner Mongol; 1999: 87–123 (in Chinese)
- [5] Shen Dingzhu. *The Application of SPA in Sports*. Beijing: The Cultural and Educational Press; 2007: 14–27 (in Chinese)
- [6] Shao Zhuyan. Set pair analysis model of forecast epidemic cerebrospinal meningitis incidence. *Journal of Jining Medical College*, 2006; 29(3), p43–44
- [7] Chen Yanqing. *Neural Networks Theory and Its Applications in Control Engineering*. Xian: Northwest Industry University Press; 1991: 32–45 (in Chinese)
- [8] Cao Hongxing. *General System Perimeter Theory-Periphery Theory*. Beijing: Science and Document Press; 1997: 42–46 (in Chinese)
- [9] Nguyen D.H., Widrow B. Neural Networks for Self-Learning Control Systems. *IEEE Control Systems Magazine*, 1990(4): p.18–23
- [10] Hecht-Nielsen R. Theory of the Back Propagation Neural Networks. *Proc. of IJCNN*, 1989(1): p.593–603
- [11] Wang Wensheng. *Set Pair Analysis for Hydrology and Water Resources Systems*. Beijing: Science Press; 2010: 17–25 (in Chinese)